Economic Impacts of Different Post-Kyoto Regimes

Christian Lutz, Kirsten S. Wiebe

Gesellschaft für Wirtschaftliche Strukturforschung, GWS mbH, Osnabrück, Germany

wiebe@gws-os.com

Abstract- **This paper analyzes world-wide macroeconomic implications of different post-Kyoto agreements and participation in emission trading schemes (ETS). The policy scenarios are based on the Copenhagen Accord, assuming that the EU completely implements its climate and energy package until 2020. For this, a detailed optimization model of European power generation and the global economy-energy-environment model GINFORS were used to carry out different scenario analyses.**

The baseline scenario assumes that the EU alone implements a post-Kyoto regime in the form of the 20-20-20 targets. For the scenarios, the EU cuts emissions by 30% compared to 1990. The four scenarios further differ from the baseline with respect to the commitments and participation of other industrialised countries and the major emerging economies, e.g. only fulfilling their minimum emission reductions as stated in the Copenhagen Accord or realizing their respective maximum reduction targets.

Keywords- Climate Policy; Post-Kyoto Agreement; Economic Modelling

I INTRODUCTION

The global climate protection action in form of the Kyoto protocol ends in 2012. The Kyoto protocol sets binding greenhouse gas (GHG) reduction targets for the industrialized countries: an average reduction of 5% in the period 2008 to 2012 compared to the countries' 1990 level of GHG emissions. After the failure of the UN climate conferences in Copenhagen in 2009 and in Cancun in 2010, different national actions have been taken and support for developing countries has been promised. The 2011 climate conference in Durban was slightly more successful. Still, a binding global agreement will if at all only be effective after 2020.

This paper analyzes world-wide macroeconomic implications of possible post-Kyoto agreements and participation in emission trading schemes (ETS). The policy scenarios are based on the Copenhagen Accord, assuming that the EU completely implements its climate and energy package until 2020, while the participation of the other countries differs. The Copenhagen Accord summarizes the non-binding emission reduction targets until 2020: the highest targets are set by the EU (20-30%), Japan (25%), Russia (15-25%) and the Ukraine (20%), all compared to 1990 levels. The other highly industrialised countries only target very low emission reduction of 5-25% compared to 2000 in case of Australia, of 17% compared to 2005 for Canada and the US, and of 30% compared to business-as-usual (BAU) development for South Korea. The large emerging economies also set reduction targets compared to their BAU development (e.g. Brazil 36.1-38.9%, Indonesia 26% Mexico 30%,, South Africa 34%) or emission intensity improvement targets compared to 2005 (e.g. China 40-45% and India 20-25%) [1].

The analysis is conducted by combining the global economy-energy-environment model GINFORS with a European power generation model. GINFORS, which covers 50 countries and 2 regions, is able to show the consequences of international climate protection regimes on the industry level. The power generation model provides electricity prices and electricity production by energy carrier for the EU27 countries and the carbon price of the EU-ETS. These results are then used as an input into GINFORS, where the ETS carbon price and a carbon tax (which is used as a proxy for different policy measures) in the non-ETS sectors are key inputs. These models and their interaction are illustrated in more detail in the next section, followed by a description of the different policy scenarios in Section 3. Section 4 presents the detailed results for emissions and carbon price. Economic impacts are explained in Section 5 and briefly compared to other studies. Some conclusions are drawn in Section 6.

II MODELLING CLIMATE POLICIES

Combining a power generation and an economy-energy-environment (E3) model yields different advantages compared to using either one of these models separately. Structural conditions and logic in both models though are quite different. The power generation sector is driven by optimization, i.e. cost minimization of large companies that operate capital-intensive power plants under different technical conditions such as net stability. Macroeconomic developments such as GDP growth, which is a main driver of electricity demand, or international energy prices, should be considered in the planning process.

The European competition in the energy sector is bottlenecked by limited interconnectors at the national borders. Electricity prices differ substantially between national markets. The national markets are interlinked among others by the greenhouse gas (GHG) emission cap of the EU-ETS. For a model of the macro economy electricity is just a small part. Investment decisions for power plants follow long-term considerations. As price elasticities of electricity demand are small, in the short and medium term electricity prices may have a significant effect on cost structures, thus linking power generation and macro economic issues.

For the scenario analysis a detailed optimization model of the European power generation industry and the global GINFORS model, which covers 50 countries and 2 regions, are used. GINFORS (Global INterindustry FORecasting System) is an economy-energy-environment model that is able to show the consequences of international climate protection regimes on the industry level. The power generation model provides electricity prices and electricity production by energy carrier for the EU27 countries and the carbon price of the EU-ETS. These results are then used as an input into GINFORS, where the ETS carbon price and a carbon tax (which is used as a proxy for different policy measures) in the non-ETS sectors

are key variables.

The power generation model replicates all large scale (> 30 MW) power plants in the EU. This gives supply of and wholesale prices for electricity in all 27 EU countries [2]. Prices are determined using merit orders. The model differentiates between 15 plant types according to energy carriers and production principles. Prices are functions of fuel and CO_2 prices, power plant efficiency and variable operation costs. Both certificate prices and energy-related CO_2 emissions can be calculated endogenously in the model by giving development paths for the other; that is a price which translates via supply and demand into emissions, or an emissions cap which then determines the certificate price via supply and demand.

The sectorally disaggregated global energy-environment-economy model GINFORS combines econometric-statistical analysis with input-output analysis embedded in a complete macroeconomic framework ensuring the accounting identities of the system of national accounts. GINFORS has recently been applied to various economic questions, ranging from an European environmental tax reform [3, 4] and environmental and economic effects of Post-Kyoto regimes [5] to the impact of higher energy prices through international trade [6]. A detailed description of GINFORS can be found in [3].

The main difference to neoclassical CGE models is the representation of prices, which are determined from the mark-up hypothesis by unit costs and not specified as long run competitive prices. But this does not mean that the model is demand side driven, as the use of input-output models might suggest. Even though demand determines production, all demand variables depend on relative prices that are given by unit costs of the firms using the mark-up hypothesis, which is typical for oligopolistic markets. The difference between CGE models and GINFORS can be found in the underlying market structure and not in the accentuation of either market side. Firms are setting prices depending on their costs and on the prices of competing imports. Demand is reacting to price signals and thus determining production. Hence, the modelling of GINFORS includes both demand and supply side elements.

Behavioural parameters of the model are estimated econometrically, and different specifications of the functions are tested against each other, which gives the model an empirical validation. An additional confirmation of the model structure as a whole is given by the convergence property of the solution which has to be fulfilled year by year. The econometric estimations are based on times series from OECD, IMF and IEA for 1980 to 2006. The modelling philosophy of GINFORS is close to that of INFORUM type modelling [7] and to that of the model E3ME of Cambridge Econometrics [8].

Electricity prices, EU-ETS carbon price and the input structure of the national power sectors are taken from the power generation model. For the non-ETS sectors an EU-wide uniform carbon tax is introduced to reach the EU reduction target for this sector. The modelling of the CO_2 price in the ETS sectors in Europe and other industrialised countries is very close to the real policy measures, while policy measures in the non-ETS sectors vary substantially and are not easily modelled. The CO_2 price for these sectors, which is used in this analysis, should therefore be interpreted only as a shadow price indicating the emission reduction burden.

III SCENARIOS OF POTENTIAL POST-KYOTO FRAMEWORKS

The baseline scenario assumes that the EU unilaterally implements a post-Kyoto regime in the form of the 20-20-20 targets. For scenarios I to IV, the EU cuts emissions by 30% in 2020 compared to 1990. The four scenarios further differ from the baseline scenario with respect to the commitments and participation of other industrialised countries and the major emerging economies, e.g. only fulfilling their minimum emission reductions as stated in the Copenhagen Accord [9] or realizing their respective maximum reduction targets.

The baseline scenario assumes an EU wide 20% reduction in greenhouse gas (GHG) emissions in 2020 compared to 1990, few CDM (clean development mechanism) measures, i.e. at most 25%, and expansion of renewable energies according to national action plans (NAP). The rest of the world follows business-as-usual, that is the Copenhagen Accord will not be met.

The assumptions for the alternative scenarios are first that the EU reduces total emissions by 30%, second, CDM measures are allowed to be up to 50% of total emission reduction. The price of these measures is 90% of the lowest CO_2-certificate price in industrialised countries [2], and third, transfers to low income countries for adaptation measures excluding GHG reduction increase from 10 billion Euros in 2012 to 35 billion Euro in 2020.

The scenarios differ in the participation of the remaining, i.e. non-EU, industrialized countries and the newly emerging economies. This is for Scenario I that all countries commit to their lowest target in the Copenhagen Accord, while their actions for Scenario II comply with the highest commitments made in the Accord. Germany decreases emissions by 40% in both Scenarios I and II. Scenario III, based on scenario II, aims at a more equal burden sharing by adapting CO_2 prices for the non-ETS sectors in selected EU and non-EU countries in a way that their GDP-loss compared to the baseline is comparable to the macroeconomic costs borne by Germany. Based on Scenario III, Scenario IV calculates additional CO_2 certificate costs necessary to reach a global emission path that is equivalent to the 450ppm scenario from the 2009 World Energy Outlook [10], ensuring the attainment of the 2° target.

IV CARBON PRICES AND EMISSIONS

In the EU the CO_2 cap until 2020 was set in October 2010 for the 20-20-20 targets. It will be reduced by 1.74% every year from 2013 to 2020. In case of a further increase in emission reduction to 30% within the EU, as is assumed for Scenarios I through IV, the cap will be altered accordingly. Following EU legislation the ETS sector is responsible for about two thirds of total necessary reduction, while services sectors, transportation and households bear the remaining third.

The EU electricity production is based on the baseline scenario in [11], but adapted for the global economic crises. The underlying assumption is an increase in EU electricity use of 17.4% until 2020 compared to 2005. This is in line with [12], where the new baseline projects that the cumulated electricity

demand for the period between 2005 and 2050 is about 7% lower, translating into an increase in EU electricity demand of about 15% to 17% between 2005 and 2020.

The EU-ETS allowance price corresponding to the CO_2 cap and electricity use for the 20% reduction scenario reaches 28 EUR (in constant 2008 prices) per tonne in 2020, whereas it rises to as much as 40 EUR (in constant 2008 prices) for a reduction in CO_2 emissions in the EU of 30%. The resulting average EU electricity prices are 66 EUR/MWh in the baseline and 72 EUR/MWh in the 30% reduction scenarios. As electricity prices differ across European countries, the price displayed here is weighted according to each country's electricity production.

The EU-27 decreases its emission by 450 Mt between 2005 and 2020 in the reference scenario alone as can be seen in Figure 1. The new member states (NMS-12) only contribute a reduction of 32 Mt. The other industrialized countries as well as the newly emerging economies (G-5: China, India, Brazil, Mexico and South Africa) and the rest of the world emit substantially more CO_2 in 2020 than in 2005. Chinese emissions increase by far the most with more than 4500 Mt.

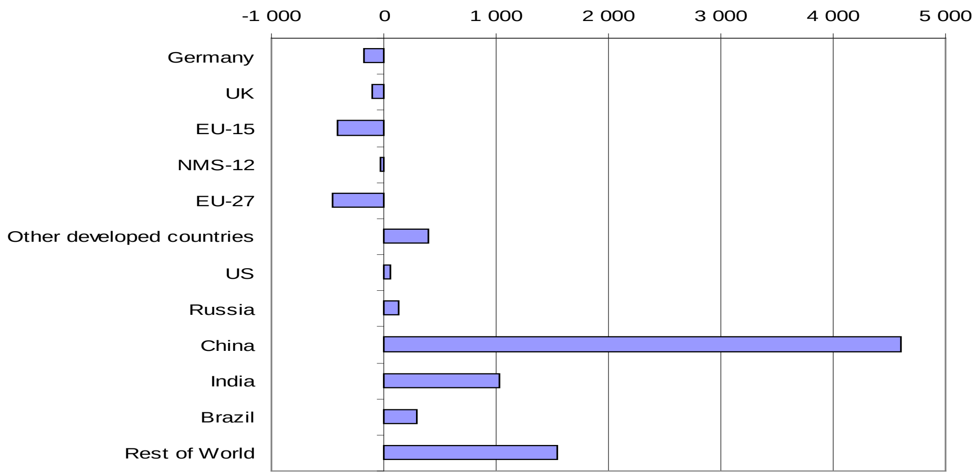

Figure 1 Change in CO2 emissions between 2005 and 2020 in Mt (baseline scenario)

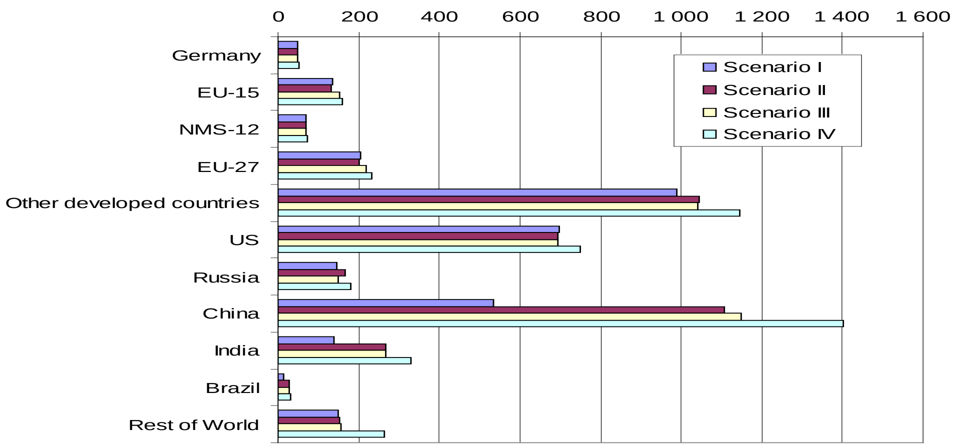

Figure 2 Reduction in CO2 emissions compared to baseline in 2020 in Mt

Figure 2 displays the reduction in CO_2 emissions for Scenarios I to IV compared to the reference scenario. The 40% emissions decrease in Germany results in an additional 50 Mt emissions saving in Scenarios I and II, which is one quarter of the total reduction within the EU.

Committing to the minimal targets offered in the Copenhagen Accord already results in emission savings of almost 1000 Mt in the other industrialized countries in Scenario I compared to the reference scenario. This in turn means that total emissions of this country group in 2020 are lower than in 2005. The highest share of this decrease can be allotted to the US with about 700 Mt, though the reduction in Scenario I is slightly higher than in Scenarios II and III. The more equal burden sharing Scenarios III and IV do not result in lower emission reductions in Germany.

For the other countries by far the highest reduction is achieved in Scenario IV, followed by III, II, and I. This is especially true for China, where the reduction in Scenario I amounts to 550 Mt only whereas it is 1400 Mt in Scenario IV.

Figure 3 shows the contribution to emission reduction of the OECD+ group of countries, that is the OECD countries plus the EU countries that do not yet belong to the OECD, and all other countries, i.e. Non-OECD+, as well as the contribution of flexible mechanisms (CDM) for which OECD+ countries finance CO_2 emission reductions in Non-OECD+ countries. Due to lower mitigation costs in Non-

OECD+ countries, the OECD+ countries fully utilize mitigation possibilities in form of CDM.

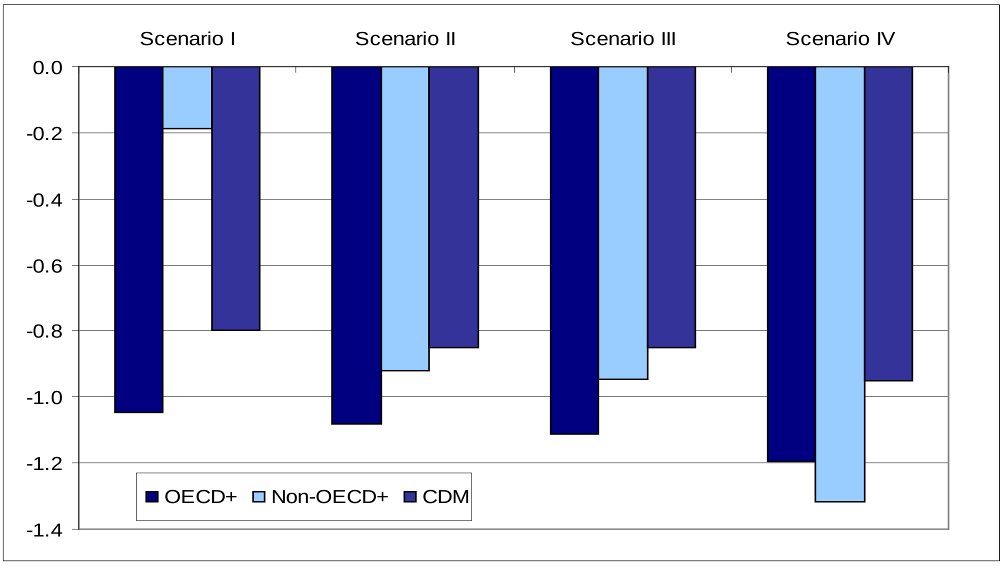

Figure 3 Contribution to CO_2 emissions reduction compared to baseline in2020 in Mt

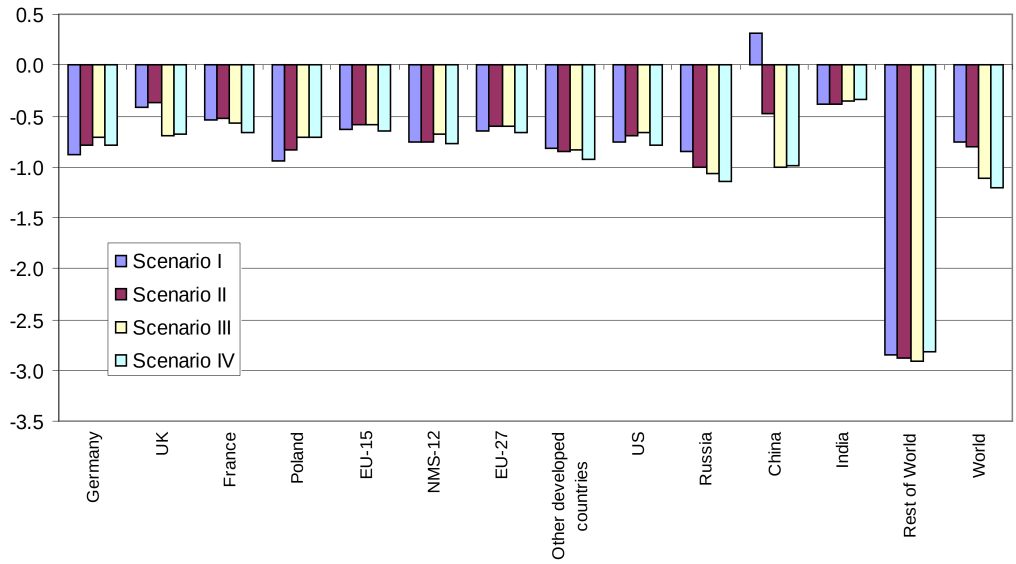

Figure 4 Effects on GDP compared to baseline in 2020 in %

V ECONOMIC IMPACTS

Generally, there is a negative effect of the possible post-Kyoto agreements on GDP, as displayed in Figure 4, which shows the percentage deviation of GDP in the different scenarios from the reference. Scenarios III and IV have indeed lower economic costs for Germany than scenarios I and II, even though the total reduction in emissions is not less. For the other highly developed EU countries such as the UK and France the more equal burden sharing though increases the costs of climate change mitigation. Economic growth in the EU is less effected than growth in the other developed countries in all scenarios. As the EU is assumed to commit to a 30% reduction in Scenario I already, while the other countries only commit to their minimum offer in the Copenhagen Accord, the negative impacts of Scenario I in the EU are higher than in Scenarios II and III. China even profits from the burden sharing in Scenario I with a GDP that is about 0.3% higher than in the reference. The negative effect in Scenario II is still rather low with less than 0.5%, while the macroeconomic costs of climate change mitigation measures as assumed in Scenarios III and IV amount to almost -1.0%. For Russia as a large oil and gas exporter negative GDP impacts will be above average.

The highest negative impacts percentage wise are experienced in the rest of the world (incl. oil and gas exporting countries), which includes all non-EU and non-OECD countries, except the large emerging economies, even though the absolute reduction in CO2 emissions are rather low. Yet, the scenario with the highest climate change mitigation efforts, Scenario IV, has the least negative effect on this country group.

TABLE I MACROECONOMIC EFFECTS IN GERMANY FOR SCENARIO I COMPARED TO BASELINE 2020

Germany 2020	Deviation from baseline	
	in %	absolute
GDP (billion Euro 2005)	-0.88	-21.3
Private consumption	-0.77	-8.3
Government consumption	-1.20	-4.9
Investment	-0.63	-2.7
Exports	-1.06	-17.4
Imports	-1.06	-12.0
Employment (in 1000)	-0.22	-81.1
Consumer price index (1995 = 100)	0.87	1.3
Average hourly wage in Euro	0.20	0.3

TABLE II SECTORAL EMPLOYMENT EFFECTS IN GERMANY FOR SCENARIO I COMPARED TO BASELINE 2020

Employment in Germany in 2020	Deviation from baseline	
	in %	absolute
Agriculture and forestry	0.7	2.6
Manufacturing industries	-0.4	-30.0
Chemicals	-0.1	-0.4
Iron and Steel	-1.1	-1.8
Non-ferrous metals	-0.2	-0.2
Machinery and equipment	-0.5	-5.4
Vehicles	-0.4	-3.7
Construction	0.5	5.5
Trade, hotels and restaurants, transport	0.2	13.4
Business activities	-1.0	-37.2
Other services	-0.3	-35.4
Total	-0.2	-81.1

Tables 1 and 2 show more detailed results for Germany for Scenario I. Recall that in Scenario I Germany reduces its emissions by 40% compared to 1990 and therefore experiences comparably high negative economic effects, with a reduction in GDP by 0.88% compared to the reference. Exports and imports decrease most in absolute terms, while investments are cut by “only” 0.63% or 2.7 billion Euros. As wages increase slower than consumer prices, employment effects are rather low with -0.22% in total. From the total reduction of 80,000 employees compared to the reference, 30,000 positions are cut in the manufacturing industries and more than 70,000 in business activities and other services. The reduction in these sectors is partly offset by employment increases in the primary sectors as well as in construction, wholesale and retail trade, hotels and restaurants, and transport.

Possible post-Kyoto scenarios have been implemented in different models, which are reported in *inter alia* [13,14,15] and [16], Bardt [17] appraises economic impacts of a unilateral 30% emission cut in the EU relative to the 20% reduction target similar to Scenario I. He concludes that the EU-wide move to 30% given a 40% reduction of emissions in Germany rather increases the pressure on the German economy instead of weakening the negative impacts due to a more equal burden sharing among the EU. His statements though are not founded in empirical or model based analysis, but rather in political and economic considerations. Jaeger et al. [13] on the other hand claim that the benefits of the move to a 30% reduction outweigh the negative impacts if there are good incentives for investment, especially “green” investments, which in turn leads to a “new growth path” through the “mobilization of a virtuous circle of additional investment, learning-by-doing and expectation formation” (p. 7). The model analysis has been conducted by implementing different macro- and micro-economic policy measures in the GEM-E3 model. The key feature is the assumption of a renewal of the “built environment” which requires large investments that directly boost the construction sector.

Russ et al. [15] use the POLES and GEM-E3 models to analyze five different global mitigation scenarios. Similarly to the modelling approach at hand, POLES models the energy sector in detail, whereas GEM-E3 is an applied general equilibrium model of the global macro-economy. The economic impact of the central carbon mitigation scenario, which is a combination of the other four scenarios, is, with a GDP loss of -1.2% compared to the baseline in 2020, higher for the EU27 countries than according to our calculations. The impacts for the remaining countries are similar: the GDP-impact in the US for example is -0.8% in the central scenario, while it is between -0.7% to -0.8% in Scenarios I to IV calculated here. Hulme et al. [18] apply five different models and find that global mitigation costs in 2050 amount to a maximum of 2.5% of global GDP for the highest reduction scenario aiming at 400ppm.

Peterson et al [13] use the computable general equilibrium model DYE-CLIP to explore the GDP and welfare impacts of the Copenhagen Accord. GDP losses of reaching the upper targets of the Copenhagen accord are the biggest in Russia, China, India and Mexico, whereas effects for industrialized countries are small and even slightly positive for EU27 and Japan. The order of these impacts is close to the GINFORS

results, but the reported differences are considerably higher in the DYE-CLIP analysis.

Den Elzen et al. [19] report quite similar country abatement costs for reaching the Copenhagen Accord, even if substantial financial transfers from industrialized countries are taken into account.

VI CONCLUDING REMARKS

Results for global emissions are in line with other studies. The Copenhagen Accord is not sufficient for reaching the 2° target. The upper bound of the Copenhagen commitments leads to similar - slightly negative - GDP impacts for the major economies in comparison to the baseline. Further, the scenario analyses indicate that for the industrialised countries the maximum commitments from the Copenhagen Accord almost completely exploit cheap mitigation possibilities whereas there still exist comparably cheap mitigation potentials in the emerging economies, especially in China. Mechanisms to exploit and finance these potentials should be high on the agenda of upcoming climate negotiations. The results give some justification for financial transfers as part of a comprehensive post-Kyoto agreement, as GDP losses in Non-OECD countries are substantially higher while abatement cost are lower than in OECD+ countries [20].

Even though the economic impacts of the mitigation scenarios compared to scenarios with no or only little mitigation discovered in the various studies are generally negative, this does not imply that international climate protection actions should not be undertaken. These negative impacts should rather be compared to the long-term costs of no climate protection action, i.e. of climate change. Rough estimates of for example [21] are that climate change damage and necessary adaptation measures will in the long run come with significantly higher costs than those of climate mitigation actions today. This is in line with other research such as [22].

REFERENCES

[1] http://www.usclimatenetwork.org/policy/copenhagen-accord commitments.

[2] Prognos, "The Future of Coal in Europe". Study for Eurocoal. Brussels, 2007.

[3] C. Lutz, B. Meyer, and M.I. Wolter, "The global multisector/multicountry 3E-model GINFORS: A description of the model and a baseline forecast for global energy demand and CO2 emissions", in International Journal of Global Environmental Issues, vol. 10(1-2), 2010, pp. 25-45.

[4] T. Barker, C. Lutz, B- Meyer, H. Pollitt, S. Speck, "Modelling an ETR for Europe," in P. Ekinsm, S. Speck, "Environmental Tax Reform (ETR)– A Policy for green Growth", Oxford University Press, New York, 2011a, pp. 204-235.

[5] C. Lutz, B. Meyer, "Economic impacts of higher oil and gas prices. The role of international trade for Germany", in Energy Economics, vol. 31, pp. 882-887, 2009b, 10.1016/j.eneco.2009.05.009.

[6] C. Lutz, B. Meyer, "Environmental and Economic Effects of Post-Kyoto Carbon Regimes. Results of Simulations with the Global Model GINFORS", in Energy Policy, vol. 37, pp. 1758-1766, 2009a, 10.1016/j.enpol.2009.01.015.

[7] C. Almon, "The INFORUM Approach to interindustry Modeling", in Economic Systems Research, vol. 3(1), 1991.

[8] T. Barker, C. Lutz, B. Meyer, H. Pollitt, "Models for Projecting the Impacts of ETR", in Environmental Tax Reform(ETR) – A Policy for Green Growth, P. Ekins, S. Speck, Eds. Oxford University Press, New York, 2011b, pp. 175-203.

[9] UNFCCC (United Nations Framework Convention on Climate Change), "Copenhagen Accord", 2009, FCCC/CP/2009/L.7.

[10] International Energy Agency (IEA), " World Energy Outlook 2009", Paris, 2009.

[11] DG TREN, " European Energy and Transport. Trends to 2030 – Update 2007", Luxembourg, 2008.

[12] DG TREN, "EU Energy Trends to 2030 – Update 2009", Luxembourg, 2010.

[13] C.C. Jaeger, L. Paroussos, D. Mangalagiu, R. Kupers, A. Mandel, J.D. Tàbara, "A new growth path for Europe – Generating prosperity and jobs in the low-carbon economy", Final Report, Potsdam, 2011.

[14] E. Peterson, J. Schleich, V. Duscha, "Environmental and economic effects of the Copenhagen pledges and more ambitious emission reduction targets", in Energy Policy, vol. 39, pp. 3967-3708, 2011.

[15] P. Russ, J-C. Ciscar, B. Saveyn, A. Soria, L. Szábó, T. Van Ieland, D. Van Regemorter, R. Virdis, "Economic Assessment of Post-2012 Global Climate Polivies. Analysis of Greenhouse Gas Emission Reduction Scenarios with the POLES and GEM-E3 models", Luxembourg, 2010.

[16] M. Amann, P. Rafaj, N. Höhne, "GHG mitigation potentials in Annex I countries – Comparison of model estimates for 2020", Interim Report IR-09-034, IIASA Luxembourg, 2009.

[17] H. Bardt, " Wirtschaftliche Kosten eines einseitigen 20 Prozent Klimaschutzziels der EU, Kurzexpertise", Institut der deutschen Wirtschaft, Köln, Januar 2011.

[18] M. Hulme, H. Neufeldt, H. Coyler, A. Ritchie, Eds. "Adaption and Mitigation Strategies: Supporting European Climate Policy", The final Report from the ADAM Project, Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, June 2009.

[19] M. den Elzen, A. Hof, A. Mendoza Beltran, G. Grassi, M. Roelfsema, B. van Ruijven, J. van Vliet, D. van Vuuren, "The Copenhagen Accord: abatement costs and carbon prices resulting from the submissions", Environmental Science & Policy, vol. 14, pp. 28-39, 2011.

[20] A. Hof, M. den Elzen, A. Mendoza Beltran, "Predictability, equitability and a dequacy of post-2012 international climate financing proposals", Environmental Science & Policy, vol 14, pp. 615-627, 2011.

[21] N. Stern, "The Economics of Climate Change", Cambridge, 2007.

[22] M. den Elzen, D.P. van Vuuren, J. van Vliet, "Postponing emission reductions from 2020 to 2030 increases climate risks and long-term costs", Climate Change, vol. 99, pp. 313-320, 2010.